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Abstract

This article discusses the functions and effectiveness of games and simulations in the learning processes, in particular as an experiential learning methodology. The application of the game Lemonade Tycoon in the development of lean manufacturing concepts is described. This article addresses the use of the game to teach the principles of lean enterprise, including zero waiting time, zero inventory, scheduling, internal customer pull instead of push system, batch to flow, cut batch sizes, line balancing, and cut actual process times. Other outcomes of learning such as promoting communication and interaction, facilitating cooperative learning, encouraging peer learning and fostering teamwork are also discussed. Games and simulations are relevant in all of the four learning phases of experiential learning and have a very positive impact on the learning and future application of lean manufacturing principles. Games are especially relevant in the generalization and application phases by helping shift learner's personal paradigms.

Keywords

batch to flow, cut batch sizes, experiential learning, games, internal customer pull instead of push system, lean manufacturing, Lemonade Tycoon, line balancing, phases of experiential learning, principles of lean enterprise, scheduling, simulation, zero inventory, zero waiting time

Games and simulations in the academic environment seem to evoke mixed reactions. On one hand, many are concerned about the effectiveness of the games and simulations in developing learning concepts (Ruben, 1999). On the other hand, it seems that some games or simulations, such as the popular SimCity series, have been found to be quite instructive but not able to sustain the interest of learners (Adams, 1998).

Interest in simulations and computer games by educators has been on the increase in recent years, and there may be several reasons for this academic interest. First, there

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has been an increasing shift from didactic teacher-centered lecture-based instruction to more learner-centered modes of instruction that emphasize active learner roles (Garris, Ahlers, & Driskell, 2002). These new interactive technologies have provided opportunities to create learning environments that actively involve students in concept development, collaborative and cooperative learning, skill development, and problem solving. Secondly, games and simulations have been shown to be effective tools for enhancing the learning and understanding of complex concepts (Cordova & Lepper, 1996). Lastly, the vast majority of students entering college and the workforce for the first time belong to Generation Y or the Net Generation, also called the dot.com generation. For this aptly named generation, games and simulations provide an enormously compelling and rewarding experience. The challenge for educators is to exploit the motivational factors of games and simulations while facilitating learning and accomplishing instructional objectives (Garris et al., 2002).

Defining Games and Simulations

There is no consensus for the definitions of games and simulations. Simulations have been defined by some as representations of some real-world phenomenon or imitations of a system, process, or environment that can also take on some aspects of reality for players or participants (Crookall & Saunders, 1989; Forsen-Nyberg & Haramaki, 1998). Key features of simulations include real-world representations systems, rules and strategies that allow simulation activity to develop, and a low-risk or risk-free learning environment that protects participants from the consequences of mistakes (Connolly & Stansfield, 2007). In contrast, games do not represent any real-world phenomenon or system; the game is the end in itself. Like simulations, games also contain rules and strategies, and while the risks taken in a game may result in negative consequences, they are still contained within the game world (Crookall, Oxford, & Saunders, 1987).

A game is an activity that is voluntary and enjoyable, separate from the real world, uncertain, unproductive in that the activity does not produce any goods of external value, and governed by rules (Garris et al., 2002). While generally games and simulations are considered similar in many respects, it is important to remember that the key distinction is that simulations propose to represent reality, whereas games do not. This is an important distinction to take into account when considering the desired learning outcomes for participants.

Effectiveness of Games and Simulations

Studies have shown that incorporating games into instruction leads to improved learning (Ricci, Salas, & Cannon-Bowers, 1996). For example, including a variable payoff schedule into a simulation game was found to lead to increased risk taking among participants, which resulted in greater persistence on the task and improved performance. Instruction that included games enhanced participant motivation, leading to greater attention to training content and greater retention (Ricci et al., 1996).

Simulations enrich the learning experience by providing a multimedia, interactive, and collaborative environment. Simulations enhance the understanding of strategic management and marketing concepts; they effectively promote cognitive learning and strengthen certain kinds of learning but not all. DeKanter (2006) suggests that when matched with the appropriate content, multiplayer games offer a three-dimensional learning construct. In this learning environment, there are teacher-participant and participant-participant interactions with the entire classroom discussing the causes and effects of a game scenario. The characteristics of instructional games and simulations are closely aligned to the theoretical principals of constructivism:

1. Relate learning activities to a larger task or problem.
2. Support the participants in developing ownership of problem or task.
3. Tasks should be authentic.
4. Tasks and the learning environment should reflect the complexity of the real world.
5. Provide the participants with opportunities to own the solution development process.
6. Learning environment should support and challenge the learner's thinking.
7. Allow for testing ideas against alternative views and alternative contexts.
8. Provide opportunity for reflection on both the content learned and the learning process (DeKanter, 2006).

Figure 1 shows a constructivist learning model (DeKanter, 2006) illustrating the interconnectedness of these elements.

Simulations, Games, and Experiential Learning

Instructional games and simulations by virtue are experiential learning activities. The experiential learning cycle developed by Kolb (1984) provides a framework for contextualizing instructional games and simulations. There are four steps inside the cycle and three steps that involve getting into and out of the cycle. To begin every session, the instructor must set the climate and focus participant attention. Without this, participants may not understand the purpose of the game or simulation. Depending on the design, deductive or inductive, the instructor may introduce the goals at the beginning or end of the session or both. However, it is important to inform participants of the goals and objectives of the game or simulation. Finally, the instructor must bring closure to the session by debriefing, tying concepts together, and advising participants of subsequent activities.

The experiential learning cycle, shown in Figure 2, has four parts inside the cycle outlined below (Kolb, 1984):

experience: the activity phase

processing: sharing reactions and observations; discussing patterns and dynamics

generalizing: developing real-world principles

applying: planning effective use of learning

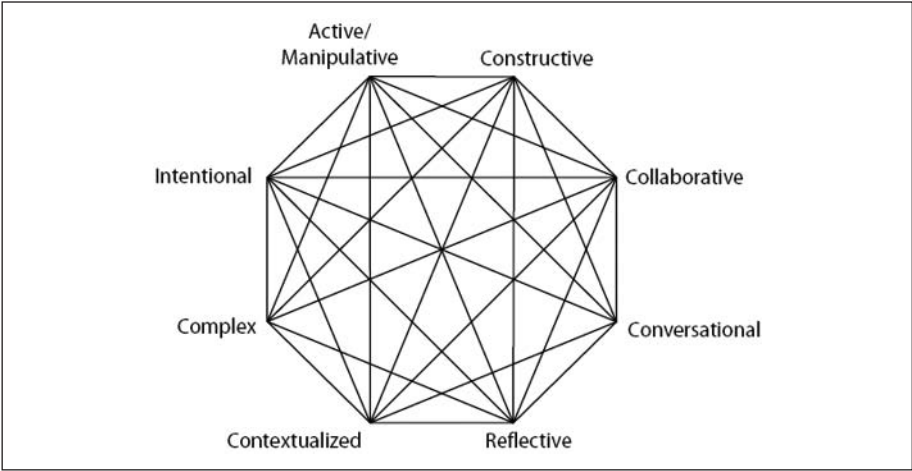


Figure 1. Constructivist Learning Model (Dekanter, 2006)

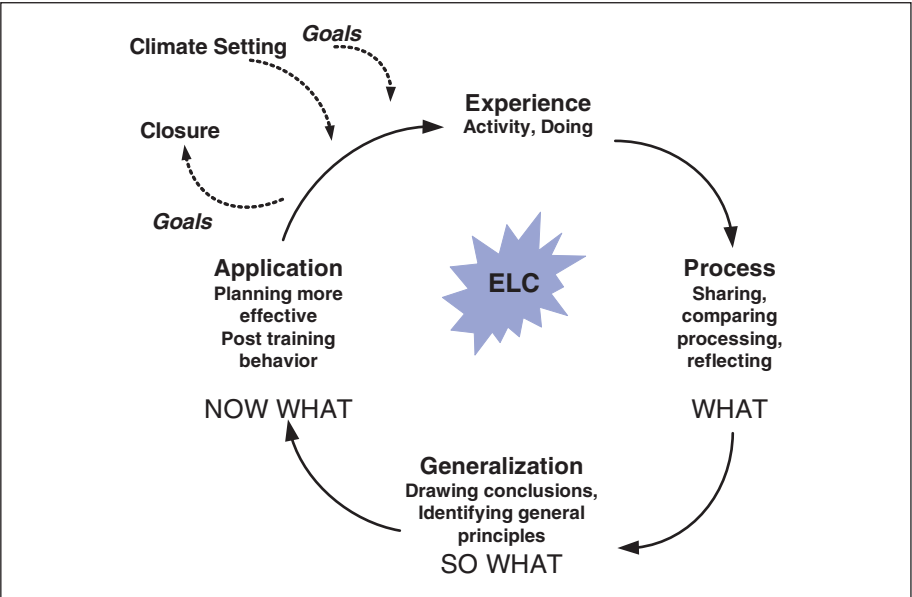


Figure 2. Experiential Learning Cycle (Kolb 1984)

Description of Lemonade Tycoon 2:The Game

The objective of Lemonade Tycoon 2 was to provide students with a significant learning experience involving concrete industrial and business situations, allowing

them to bridge the gap between content and the academic environment and the real world. The team approach was used, and team members were allowed a specific period to develop a strategy for the business venture involving the sale of a manufactured product—lemonade.

The appeal of *Lemonade Tycoon 2*, New York edition lies in its simplicity, requiring the players to make a host of decisions and allowing them to easily explore the impact of their choices. *Lemonade Tycoon 2* has three game play modes: Time Challenge, Money Challenge, and Career. In the Time Challenge mode, players try to make as much money as they can within a time limit that they decide on at the start of the game. In Money Challenge, the main objective is to play until the money limit set at the start is reached. The Time Challenge and Money Challenge modes feature similar game plays, because players have to meet an objective. The third mode is the Career, which is an open-ended game focused on building a thriving and sustainable business. The Career mode of the game allows players to compete with the game itself, without worrying about whether or not they can finish before time runs out. The game spans different districts of New York (Tycoon Games Review.com).

Starting *Lemonade Tycoon 2* players have an option of following the walkthrough or playing by themselves. Players start with a free lemonade stand in the Bronx and \$500 (see Figure 3). Then, they choose a recipe for lemonade, purchase supplies, and set the price per cup of the lemonade.

The day starts with the opening of the lemonade stand and customers coming to buy lemonade. When business picks up, players can hire employees and invest in calculators, advertising, and other upgrades (Adams, 1998). Players have to make sure they have enough stock and that their recipe takes into account the weather report for the next day. The weather plays a big role in the success, and learning what customers like is a part of that success (Tycoon Games Review.com). Players control their marketing budget, stock levels, recipes, and prices. They can also upgrade their stand with items that speed transactions, draw more patrons, or keep people in line longer. The game can be speeded up by fast-forwarding or skipping straight to the evening to check receipts, track the company's profits and losses, order stock for the following day, and more.

Players start small, focusing on the basics. *Lemonade Tycoon 2* is a business simulation for uncertain times (Cohen, 2005). Beginning with a small stand on a street corner, players buy supplies, mix up a batch of lemonade, and sell lemonade. If their price is too high, the line is too long, or the recipe is unappealing, customers disappear and players are stuck with melted ice and spoiled lemons (Spence, 2003). The animations of customers ambling by and issuing thought balloons are quite fascinating. *Lemonade Tycoon 2* as simulation can be very interesting and educational. Not only must players set the right price and buy appropriate supplies, they have to contend with the weather, market awareness, demographics, and advertising issues. The *Lemonade Stock Exchange* even allows players to share scores with other *Lemonade Tycoon 2* players online (Spence, 2003).

Although the program is primarily designed for pleasure and contains a number of gross simplifications of manufacturing and venture capitalism, it provides a teaching



Figure 3. Screenshot of Times Square Stand

tool with special strengths when placed in the context of other modes of business and industrial manufacturing instruction (Marc, 1995). These strengths include the ability to represent attractively a complex system, as well as great flexibility in scale of representation, coordinated representation of pattern and process, a pedagogical environment which is conducive to critique of familiar industrial and business patterns and processes, and a hint of the complexity of issues facing business people and manufacturers (Marc, 1995).

As a management or business game, *Lemonade Tycoon 2* qualifies very well as a simulation. Not only does it reflect reality and promote social communication, but it also allows for the evaluation of reality with self-evaluation and reflection (Kryukov & Kryukova, 1986; Wall & Ahmed, 2008). Simulation is a flexible tool that allows the visualization and quantification of technological as well as operational changes in processes for the decision maker (Washbush & Gosen, 2001). *Lemonade Tycoon* while simple to play, still puts players into complex realistic situations. It also has the added advantage of being flexible and adaptable and can be applied to a variety of other management and business contexts, including marketing, decision making, and forecasting among others.

Facilitating the Learning of Lean Manufacturing Principles

Teams played the Lemonade Tycoon game as an approach to learning lean manufacturing. The goals of this exercise were to apply lean manufacturing concepts and throughput time using the pull system to explain and illustrate the concepts of push and pull (*kanban*), bottleneck, cycle time, and idle time. The game did not effectively illustrate other lean principles, including line balance and worker behavior in an operational setting. Lean is more than just cutting costs in the factory. One crucial insight was that most costs were assigned when a product was designed (Yazici, 2006). Good organizational management principles required the development and review checklists to review product designs. Key lean manufacturing principles learned included the following:

- Pull processing: Products are pulled from the consumer end (demand), not pushed from the production end (supply).
- Perfect first-time quality: This refers to a quest for zero defects, revealing and solving problems at the source.
- Waste minimization: Eliminate all activities that do not add value and safety nets, and maximize the use of scarce resources (capital, people, and land).
- Continuous improvement: Reduce costs, improve quality, and increase productivity and information sharing.
- Flexibility: Produce different mixes or greater diversity of products quickly, without sacrificing efficiency at lower volumes of production.
- Build and maintain a long-term relationship with suppliers through collaborative risk sharing, cost sharing, and information sharing arrangements (Carlino & Flinchbaugh, 2005; Yazici, 2006).

Lean production is aimed at the elimination of waste in every area of production, including customer relations, product design, supplier networks, and factory management. Its goal is to incorporate less human effort, less inventory, less time to develop products, and less space to become highly responsive to customer demand while producing top quality products in the most efficient and economical manner possible.

Lean manufacturing is a management philosophy focusing on reduction of seven resources that are commonly wasted, to improve customer value (Carlino & Flinchbaugh, 2005; Ohno, 1988). Technically, there are now nine “deadly wastes”:

- Defects: Defective products and quality defects are unacceptable to the customer. The effort involved in inspecting for and fixing defects results in wasted time, energy, and resources.
- Overproduction: Making more than what is needed or making it earlier than needed results in excess products; these are wasted when they are not sold to the customer.
- Transportation/Conveyance: Moving products farther than is minimally required results in unnecessary movement, which is costly as it has no added

value. Every time a product is moved, there is chance that it will be damaged, lost, or delayed.

- **Waiting:** This refers to products waiting on the next production step or people waiting for work to do. Time spent waiting for resources to arrive, queuing products to empty, and delayed delivery to the customer is waste.
- **Inventory:** Raw materials, work-in-progress, or finished goods that are not being actively processed to add value are waste as they represent a capital outlay that has not yet produced an income either by the producer or for the consumer. Having more inventory than is minimally required results in waste.
- **Motion:** People moving or walking more than minimally required is a waste. Movement by the worker or equipment has significance to damage, wear, and safety.
- **Overprocessing:** The use of more costly resources than necessary or adding unnecessary features not needed by the customer represents the seventh form of waste. Overprocessing relates to standalone processes that are not linked to upstream or downstream processes.
- **Safety:** Unsafe work areas create lost work hours and expenses, which results in waste.
- **Information:** The age of electronic information and enterprise resource planning systems requires current/correct master data details (Carlino & Flinchbaugh, 2005; Mejabi, 2003; Ohno, 1988).

By eliminating waste (*muda*), quality is improved, and production time and costs are reduced. To solve the problem of waste, lean manufacturing has several mechanisms at its disposal. These include a continuous improvement process (*kaizen*), pull production (by means of *kanban*), and mistake proofing (*poka-yoke*; Carlino & Flinchbaugh, 2005).

Operation of Lemonade Tycoon

Participants were grouped into teams. Each team focused on improving business outcomes by applying lean manufacturing principles and eliminating waste. They focused on the following core concepts in their bid to improve their businesses:

1. Creativity comes before capital, which taps into the experience, innovation, and knowledge of the people working in the process.
2. An improvement not perfectly done today is better than the perfect solution done late. There is always a need for further continuous improvement.
3. Inventory is not an asset but a cost or waste.
4. There is power in teamwork and consensus through brainstorming (Alukal, 2006).



Figure 4. Feedback Report

In the interest of time, players chose the Time or Money Challenge. Teams started the day with the lemonade recipe set and supplies in place. During the course of the day, teams adjusted their resources as needed by hiring employees and investing in calculators, advertising, and purchasing other upgrades. The game has a good feedback system, which allows players to see how well they did and how good their lemonade is. The feedback system is based on whether the customers like the lemonade or not (Figure 4).

At the end of the day, teams used the feedback system to see how well they did and how good their lemonade was. Depending on how well they did, teams had to decide whether or not there was a problem. If they had a problem, they simulated the problem-solving DMAIC process. If the feedback was positive, teams could then implement continuous improvement processes. The game also provides a report that allows the players to monitor progress in terms of revenues, costs, profits, and expenses (Figure 5). Lemonade Tycoon 2's basic graphics offer a simple streetscape inhabited by small figures. Its appeal lies in finding ways to make more money.

The main steps in the lean Lemonade Tycoon 2 simulation involved developing a value stream map of the underlying process. Ferguson (2007) describes value stream

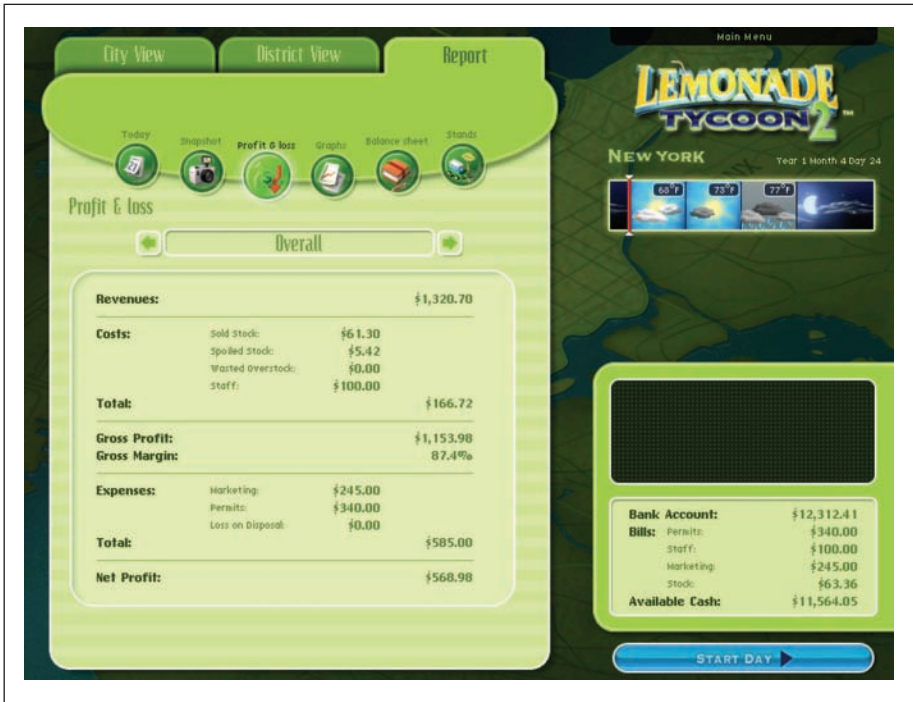


Figure 5. Profit & Loss Report

mapping as a visual way of representing the flow of information and materials in the production of products. In *Lemonade Tycoon 2*, value stream mapping helped teams relate information and product flow, and waste and helped them determine the relationship between information and supplies. To effect process management, the six sigma methodology, DMAIC (determine, measure, analyze, improve, and control), was applied as a framework for the process management (Ferguson, 2007). Figure 6 displays the simulation framework for the process management.

The first step in the process, Define, involved identifying the improvement opportunities (see options below). In the next phase, Measure, the teams developed a data collection plan to baseline the current situation and ensure that accurate and valid data required for analysis in the next phase are available. The reporting feature in the game allowed the teams to have the necessary data readily available. The Analyze step involved estimating and quantifying the current state of the process with the idea of identifying and verifying the root cause of the wasted stock, which provides an idea of the gaps to be filled (Miles, 2006; Mukherjee, 2008). The purpose of the Analyze phase was to make sense of all the information and data collected in Measure, and to use those data to confirm the source of waste and poor quality (George, Rowlands, & Kastle, 2004). In the Analyze phase, teams developed theories of root causes, confirmed the theories with data from the reporting feature in the game, and finally identified the

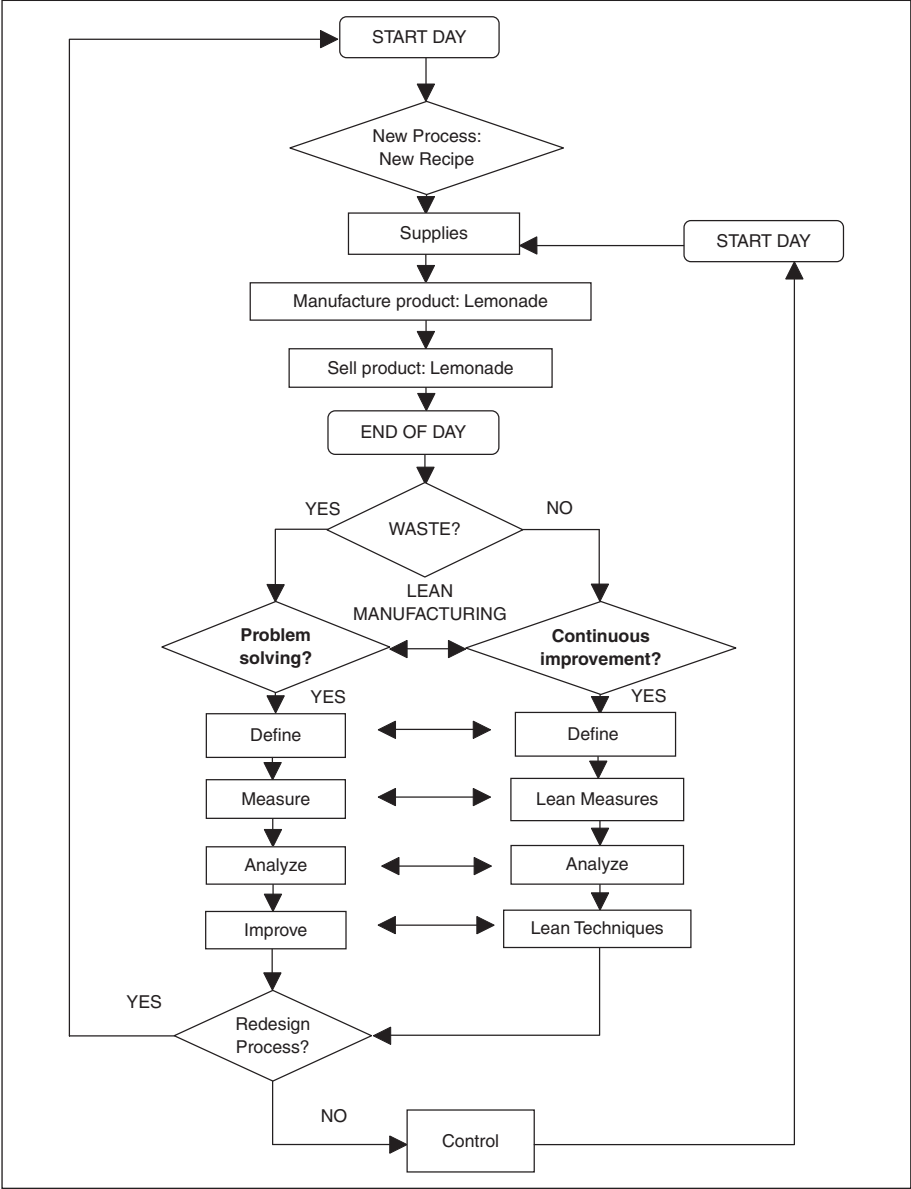


Figure 6. Simulation Flowchart for Lean Lemonade Tycoon 2™ (Modified from Al-Aomar, 2007)

root causes of the problem (Miles, 2006). The identified causes formed the basis for solutions in the Improve phase.

The purpose of the Improve phase was to make changes in the lemonade-making process that eliminated defects, waste, and cost linked to the customer needs identified

in the Define phase (Miles, 2006). In the Improve phase, teams identified a range of possible solutions, developed criteria for selecting solutions, and implemented the chosen solution the next day. Teams improved the lemonade by eliminating defects, which included anything that was unacceptable to the customer (e.g., amount of ice, number of lemons in recipe, time to service, etc.). At the end of each day, teams had to choose the lean improvement options they used to improve production and reduce waste (*muda*) for the next day.

The improvement options were as follows:

1. reduce setup times/rapid setup
2. push to pull (*kanban*)
3. team development
4. batch size reduction
5. reduce move times
6. modify order file
7. reduce processing/inspection times
8. reduce rework times
9. six sigma/total quality
10. manage work center capacities (theory of constraints)

Teams also identified the sources of waste (seven wastes) in their lemonade making business:

- inventory
- defective product
- waiting time
- overproduction
- transportation
- motion
- overprocessing

As part of the simulation, teams determined which of the seven resources were being wasted in the lemonade-making and selling process.

The purpose of Control was to make sure that any gains the team made lasted by maintaining the new strategy. During the Control phase, teams controlled their marketing budget, stock levels, recipes, and prices, and documented the new improved process (see the appendix). Analyzing the process using the flowchart improved the process, developing a future value stream map of the improved system and defining actions to main the achieved improvement (Al-Aomar, 2007).

Evaluation of the Lemonade Tycoon Simulation Game

Evidence for the effectiveness of the methodology was obtained through the use of a variation of the minute paper assessment (Angelo & Cross, 1993). This assessment

requires very little time to administer in the classroom. However, it elicits important feedback on how well teams reacted to the learning experience. Teams were asked to respond to the following questions:

- What did you learn from the game?
- What did you like the most?
- What did you like the least?
- What, if anything, do you feel has not been very helpful?
- What, if any, problems did you encounter?
- What questions on lean were not answered by the game?

Most teams indicated that playing the game helped them understand lean principles more effectively. However, they felt that they were not always able to apply all the improvement options at once. When they applied several options at the same time, they were not able to tell which option had the most impact on the outcome. Other options, such as reduction of processing or inspection times, reduction of rework times, and reduction of setup times were difficult to implement. Another limitation is that the production process is overly simplified for some real-life situations. However, despite some of the shortcomings of the game, teams felt that the game was an effective methodology. The main benefits of using Lemonade Tycoon to learn lean concepts included the following:

- Concept development: This enhanced the learning and understanding of complex concepts of lean.
- Team building: Participants learned to work effectively in teams.
- Problem solving: The game allowed the development of problem-solving skills.
- Experiential: Experiential learning was promoted, enhancing the learning environment.

Conclusion

The many advantages of using simulation techniques when teaching have been noted by a number of authors. The gaming method has advantages over case and lecture methods because participants actually become involved in the decision-making process; this approach also facilitates the introduction of integrated organizational systems, and it is possible to illustrate other concepts, including the system's life cycle and integrated central databases. Benefits of games and simulations in an academic learning environment include the following:

1. Games and simulations allow students to participate in learning activities that are otherwise too costly, too dangerous, difficult, or impractical to implement in the classroom (Berson, 1996).
2. They facilitate participant engagement in those activities that are difficult to accomplish by other means (Thomas, Cahill, & Santilli, 1997).

3. Games and simulations tend to incorporate degrees of flexibility and complexity to cater to different learning styles (Kirriemuir, 2002; Sedighian, 1994).
4. They broaden learners' exposure to different people and perspectives (Berson, 1996).
5. Games and simulations also encourage collaboration and support meaningful postgame discussion (Kirriemuir, 2002).
6. Many games and simulations have instant feedback and a risk-free environment that invites exploration and experimentation, stimulating curiosity, discovery, learning, and perseverance (Kirriemuir, 2002).
7. Competitive simulation games encourage self-learning—players have more incentive to learn because of the motivation to win.

Other significant learning benefits of computer simulation games are the use of metacognition and mental models, improved strategic thinking and insight, better psychomotor skills, and the development of analytical and spatial skills, iconic skills, visual selective attention, computer skills and so on (Green & Bavelier, 2003; Kirriemuir, 2002; Ko, 2002; Pillay, Brownlee, & Wilss, 1999).

Nevertheless, simulation presents challenges for the learner and instructor (Mitchel & Savill-Smith, 2004). Some of the disadvantages of using instructional games and simulations include the following:

1. Games and simulations require more of time to cover the same number of concepts as compared with more traditional lecture methods.
2. Games and simulations do not necessarily develop all competencies, and at times, the competencies learned are peripheral to the required skills.
3. While Lemonade Tycoon is fairly inexpensive, most other games and simulations can be expensive.
4. The simulation may not realistically portray the real world.
5. Games and simulations can quickly degenerate into horseplay resulting in confusion and noise.
6. Some computer games and simulations have software shortcomings that may cause failure and frustration.
7. Not all learners enjoy playing games.
8. The number of active participants is limited, with the rest of the team acting as spectators.

However, despite these challenges for both instructors and learners, games and simulations have real merit in the learning of dry content, inaccessible material, or complex concepts. They put the learner in the role of decision maker and push players through ever harder challenges—you learn through trial and error (Kirriemuir, 2002). A good game and simulation will allow the participants to make mistakes and learn from those mistakes in a realistic environment, without suffering the consequences of those mistakes as they would in real life (Berson, 1996).

Appendix I

Day	Sales/# of cups sold	Profit	Customer responses	Beginning Stock	End Stock	Wasted Inventory	Lean Adjustments:	Quality Improvement
1								
2								
3								
4								
5								

Assumptions and Non-customer Variables
Improvement Options: 1 Reduce Set-up Times 2 Push to Pull 3 Batch Size Reduction 4 Reduce Move Times 5 Modify Order File 6 Reduce Processing/ Inspection Times 7 Reduce Re-Work Times Improve Quality Manage Work Center Capacities (TOC)

Appendix A: One period of play-by-play data

#eid: Per Time Event Team Description
1 2:00 FACEOFF N/A Away wins
2 1:54 SHOT Away Away shoots
3 1:48 SHOT Home Home shoots
4 1:35 SHOT Away Away shoots
5 1:26 SHOT Home Home shoots
6 1:21 FACEOFF N/A Away wins
7 1:10 SHOT Away Away shoots
8 1:04 SHOT Home Home shoots
9 1:03 KARMA Home Start: 29 Delta: -11 Final: 18
10 1:03 HITTARG Home Goalie

(continued)

Appendix A (continued)

- 11 | 0:51 SHOT Away Away shoots
- 12 | 0:49 INJURY Home Home team has sustained an injury
- 13 | 0:45 SHOT Home Home shoots
- 14 | 0:41 LINECHG Home Home is changing lines
- 15 | 0:35 SHOT Away Away shoots
- 16 | 0:33 LINECHG Home Home is changing lines
- 17 | 0:33 LINECHG Home Home is changing lines
- 18 | 0:32 LINECHG Home Home is changing lines
- 19 | 0:31 SHOT Away Away shoots
- 20 | 0:21 SHOT Home Home shoots
- 21 | 0:20 SHOT Home Home shoots
- 22 | 0:16 HITFREQ Home First hit in a row
- 23 | 0:16 KARMA Home Start: 9 Delta: -7 Final: 2
- 24 | 0:16 HITTARG Home Open player
- 25 | 0:15 FACEOFF N/A Away wins
- 26 | 0:07 SHOT Away Away shoots

Appendix B: Post-play questionnaire

Five possible responses for each question, ranging from Strongly Agree to Strongly Disagree

Name: _____ Age: _____

Gender: Male or Female (Circle one)

For each of the statements below, please indicate the extent of your agreement or disagreement by placing a tick in the appropriate column.

Please answer all questions based on your experience of playing Heads Up Hockey.

- 1. Aggressive play (for example, speeding up to deliver a big hit) is important to winning at Heads Up Hockey
- 2. Changing lines every 25 seconds or so is important to winning at Heads Up Hockey
- 3. Removing injured players from the lineup is not important to winning at Heads Up Hockey
- 4. Chippy play (for example, hitting a player that doesn't have the puck) improves my chances of winning at Heads Up Hockey
- 5. Getting used to the game controls is important to winning
- 6. The more I played Heads Up Hockey, the more often I removed injured players from the lineup

(continued)

Appendix B (continued)

7. The more tired a player was in Heads Up Hockey, the more likely he was to get injured
8. The more I played Heads Up Hockey, the less aggressive I played
9. If an injured player is not removed from the lineup, the rest of the team would start playing more poorly (for example, skate slower, shoot less hard)
10. I tried my absolute best to win at Heads Up Hockey.

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Bio

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